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ABSTRACT

The reasons that cause women to take significantly fewer mathematics courses than men are investigated. The subjects consisted of 377 female college freshmen enrolled at a small, private women's liberal arts college in the Midwest. All subjects were tested as part of the college's regular placement testing program prior to the Fall semester of the 1978-79 academic year. Thirty-three of the subjects' test results were eliminated due to incomplete demographic data. Results of the remaining 344 were analyzed. Students were tested with an achievement test of 50 multiple choice items constructed by the mathematics faculty, and by 24 items gathered by the researcher to measure mathematics attitudes and anxiety. Individuals with a high level of mathematics anxiety were found to hold different attitudes towards mathematics and perform less well than those who were not mathematics-anxious. Particularly surprising findings were negative correlations for the high mathematics-anxious group with mathematics as a male domain, fathers' perceived attitudes, and attitude toward success in mathematics. The findings indicate that mathematics anxiety is a construct needing further definition, and that one's preferred sex role is a likely correlate of mathematics anxiety in females. (MP)

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RELATIONSHIP BETWEEN MATH ATTITUDES AND ACHIEVEMENT, PARENTS' OCCUPATION, AND MATH ANXIETY IN FEMALE COLLEGE FRESHMEN

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Women take significantly fewer math courses than their male counterparts in both high school and college. This may be one reason for the under-representation of women in scientific and technical occupations (U.S. Department of Labor, 1975; Wilburn, 1974). In a study of entering freshmen at the University of California-Berkeley, Sells (1973) found that 92% of the women as opposed to 57% of the men lacked the high school math prerequisites necessary for 15 of the 20 major fields at Berkeley.

Why do women take fewer high school math courses than men? Some psychologists and mathematics educators explain this fact by pointing to a phenomenon labelled math anxiety. Richardson and Suinn (1972) define math anxiety as "feelings of tension and anxiety that interfere with manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Tobias (1976) believes that math anxiety is rooted in ". . . a culture that makes mathematics ability a masculine attribute, that punishes women for doing well in mathematics, and that soothes the slower mathematics learner by telling her she does not have a 'mathematic mind'" (p. 57). Studies indicate

that women, more than men, suffer from the effects of math anxiety (Betz, 1978).

Betz (1978) and Austin-Martin, Waddell and Kincaid (1980) examined the relationship between educational and psychological factors and math anxiety in female college students. They found that math anxiety has an adverse impact on mathematics achievement and attitudes toward math; that the number of high school math courses was negatively correlated with math anxiety; and that the perceived attitudes toward math of teachers and parents were significantly and positively correlated with subjects' math anxiety. While these studies shed light on some of the effects of math anxiety, more research needs to be done in this area.

The present study investigated the relationship of math anxiety to mathematics achievement, math attitudes, and parents' occupation for female college freshmen. More specifically, we have examined: a) the characteristics of high and low math-anxious subjects; b) the relationship between math anxiety and achievement in mathematics; c) differences between high and low math-anxious subjects on attitudes toward mathematics; d) the effects of mothers' and fathers' occupations (professional or nonprofessional) on subjects' math anxiety; and e) the effects of mothers' and fathers' occupations (math-related or not math-related) on subjects' math anxiety.

METHOD

Subjects

The subjects for the study consisted of 377 female college freshmen enrolled at a small, private women's liberal arts college in the

Midwest. All subjects were tested as part of the College's regular placement testing program prior to the Fall semester of the 1978-79 academic year. Thirty-three subjects' test results were eliminated from the study because of incomplete demographic data, leaving 344 for data analysis.

Instrumentation

Mathematics achievement was measured using a 50-item multiple choice test constructed by faculty members in the Mathematics Department at the college. The test had a computed reliability of 0.93. Test validity was determined by having five members of the mathematics faculty reach 100% agreement on matching items to objectives. Attitudes toward mathematics were measured using seven scales developed by Fennema and Sherman (1976): Confidence in Learning Mathematics (C), Mother Scale (M), Father Scale (F), Teacher Scale (T), Attitude Toward Success in Mathematics (AS), Mathematics as a Male Domain (MD), and Usefulness of Mathematics (U). Math anxiety was measured using a scale also developed by Fennema and Sherman. The attitude scales and the math anxiety scale each consist of 12 items. Item responses were obtained on a 5-point Likert scale with responses ranging from 1 (strongly agree) to 5 (strongly disagree). Half of the items were positively-worded and the other half, negatively-worded. Scoring of the negatively-worded items was reversed so that a low score on a particular scale reflected either positive attitudes toward mathematics or less math anxiety. High scores indicate negative attitudes toward mathematics or high math anxiety. Subjects

reported their mothers' and fathers' occupations on a brief questionnaire.

Procedure

The subjects were administered the instruments in a group situation. All subjects were allowed unlimited time to complete the battery of tests. Each subject ranked her responses to the instruments on a computer scoring sheet. Subjects in the study were classified as high or low math-anxious by computing the mean for scores on the Mathematics Anxiety Scale; those subjects one standard deviation above the mean were classified as high math-anxious and those subjects one standard deviation below the mean as low math-anxious. Parents' occupations of subjects were categorized as professional or nonprofessional according to the classification provided in the Dictionary of Occupational Titles (U.S. Department of Labor, 1977). The math-relatedness or non-math-relatedness of parents' occupations was determined by experimenter agreement on the degree of mathematic proficiency required for adequate job performance. Where there was not clear agreement between experimenters, subjects' data were omitted from the analysis. The data were analyzed using an SPSS program (Nie, et al., 1970) for Pearson product-moment correlation and analysis of variance.

RESULTS

Means and standard deviations of scores for high and low math-anxious female college freshmen on the Mathematics Attitude Scales and the mathematics achievement test are reported in Table 1. Low math-anxious subjects had lower scores on the mathematics attitude scales with one exception--math as a male domain--, reflecting low math-

anxious subjects' more positive attitudes toward mathematics. They also had greater mathematics achievement than did high math-anxious subjects.

The relationship between math anxiety, math attitudes, and mathematics achievement for high and low math-anxious subjects is reported in Tables 2 and 3, respectively. For both high and low math-anxious subjects, confidence in ability to learn mathematics was significantly and positively related to subjects' math anxiety. The belief that mathematics is a male domain was significantly and negatively related to math anxiety for high math-anxious subjects ($r = -0.3838$, $p < .001$). As high math-anxious subjects' math anxiety increased, their view that math is a male domain decreased. Low math-anxious subjects' math anxiety was found to be significantly and positively related to their belief that math is a male domain. The more anxious low math-anxious subjects were, the more they viewed math as a male domain. Low math-anxious subjects' math anxiety was more highly correlated with mothers', fathers', and teachers' perceived attitudes toward mathematics than was the math anxiety of high math-anxious subjects. High math-anxious subjects' math anxiety appeared to be unrelated to their view that mathematics is a useful subject ($r = -0.1386$, $p > .05$). For low math-anxious subjects, as math anxiety increased, their view that mathematics is a useful subject decreased. High math-anxious subjects' attitude toward success in mathematics was significantly and negatively correlated ($r = -0.3930$, $p < .001$), but significantly and positively correlated for low math-anxious subjects ($r = 0.6201$, $p < .001$). High math-anxious subjects' achievement in mathematics was found to be unrelated to their math anxiety ($r = 0.0016$, $p > .05$), while for low math-anxious subjects, mathematics

achievement was significantly and positively related to math anxiety ($r = 0.7056$, $p < .001$). Furthermore, the correlations between math as a male domain and attitude toward success in mathematics for high and low math-anxious subjects were $r = 0.4680$ ($p < .001$) and $r = 0.9271$ ($p < .001$), respectively.

Analyses of variance of scores on the Mathematics Attitude Scales for high and low math-anxious subjects are reported in Tables 4-10. Significant differences were found between high and low math-anxious subjects' confidence in learning mathematics ($F = 34.924$, $df = 1,114$, $p < .001$). Low math-anxious subjects had significantly more confidence in their ability to learn mathematics than did high math-anxious subjects. High math-anxious subjects viewed mathematics as less of a male domain than did low math-anxious subjects ($F = 7.341$, $df = 1,114$, $p < .01$). In contrast, low math-anxious subjects viewed mathematics as more useful than did high math-anxious subjects ($F = 25.722$, $df = 1,114$, $p < .001$). Significant differences were found between high and low math-anxious subjects on the way they perceived their mothers' ($F = 5.432$, $df = 1,114$, $p < .05$), fathers' ($F = 22.309$, $df = 1,114$, $p < .001$), and teachers' ($F = 32.096$, $df = 1,114$, $p < .001$) attitudes toward mathematics. Low math-anxious subjects perceived their mothers', fathers', and teachers' attitudes toward mathematics as more positive than did high math-anxious subjects. No significant differences were found between high and low math-anxious subjects in their attitudes toward success in mathematics.

Analyses of variance of subjects' scores on the mathematics anxiety scale by parents' occupation (professional or nonprofessicnal

and math-related or not math-related) are reported in Tables 11-14. There were no significant differences in subjects' math anxiety when mothers' ($F = 0.000$, $df = 1,330$, $p > .05$) or fathers' ($F = 1.49$, $df = 1,315$, $p > .05$) occupational status, professional or nonprofessional, was considered. Likewise, there were no significant differences in subjects' math anxiety when mothers' ($F = 0.136$, $df = 1,315$, $p > .05$) or fathers' ($F = 2.75$, $df = 1,286$, $p > .05$) occupation, math-related or not math-related, was considered.

DISCUSSION

The results of the study indicated that individuals with a high level of math anxiety hold different attitudes toward math and perform less well in mathematics than those who are not math-anxious. Furthermore, the data showed that the professional or nonprofessional status or math-relatedness of parents' occupations are not related to subjects' math anxiety.

An examination of high math-anxious subjects suggested that there may be multiple sources for their math anxiety which are unrelated to and uninfluenced by attitudes toward mathematics which they hold. This group appears to be less consistent in attitudes held and therefore, less predictable, thereby making the correlates of their math anxiety harder to identify. The particularly surprising findings were the negative correlations with math as a male domain, fathers' perceived attitudes, and attitude toward success in mathematics for the high math-anxious group. It is possible that these students' attitudes are being influenced by their adherence to a traditional or nontraditional sex-

role definition and by the need to deny the importance of success in a subject area that is anxiety-producing. This suggested, further, that there may be a nonrational basis for math anxiety that is uninfluenced by one's belief system about mathematics.

Subjects who are not math-anxious hold consistently positive attitudes toward mathematics and appear to be influenced by the attitudes toward mathematics which they perceive their parents and teachers to hold. The significant and positive relationship between math anxiety and math as a male domain in this group further supported the hypothesis that one's preferred sex-role definition is an influential factor that needs to be examined in further research on the construct of math anxiety. This group may well hold a traditional view of what is an acceptable masculine or feminine activity and appears to value success in an area they consider to be a male domain. As a group, they may simply be more conforming and desirous of pleasing significant others than their high math-anxious counterparts.

When we examined differences in attitudes toward mathematics held by high and low math-anxious subjects, we found that the groups differ significantly in an expected direction in all but their attitudes toward success in mathematics, with low math-anxious subjects holding more positive attitudes toward mathematics. Both groups hold to a similar degree, a belief in the importance of success in mathematics even though they differ in their view of math as a male domain. Low math-anxious subjects may tend to adhere to a more traditional sex-role definition, as we suggested earlier, which may explain their view

of math as a masculine activity. High math-anxious subjects, on the other hand, continue to experience math anxiety, even when they do not view it as a male domain. This may mean that they adhere to a less traditional sex-role definition or that their math anxiety remains uninfluenced by their belief that mathematics is an acceptable area of endeavor for females. Further study of high math-anxious individuals is needed to further delineate the characteristics of this apparently more complicated group.

Another unanticipated finding was the lack of relationship between parents' occupations and subjects' math anxiety. Although consistent with our previous findings (Austin-Martin, Waddell and Kincaid, 1980), this was contrary to the expectation that parents, especially mothers, working in professional and math-related occupations would have an influence on their daughters' math anxiety and attitudes toward mathematics. One explanation for these findings is that math anxiety may have its roots at an early age before individuals have an awareness of the nature of their parents' occupational activity. It appeared that parents' occupations are incidental and even irrelevant to our developing understanding of factors related to math anxiety, at least for college-age subjects. Further research on math anxiety and math attitudes in children may provide further clarification of this issue. Additional research examining the perceived sex-role definition of mothers, fathers, and teachers may reveal a way in which these individuals are more than incidental in affecting math anxiety and attitudes toward mathematics in their children and students.

The findings in this study indicated that math anxiety is a construct needing further definition and that one's preferred sex-role is a likely correlate of math anxiety, especially in females, and should be carefully studied. Our research suggests, also, that a recommended treatment program for high math-anxious individuals may be more difficult to specify and plan than was initially thought. Such programs cannot simply focus on either mathematics content or math anxiety reduction since a focus on one may not affect the other. The inclusion of a consciousness-raising component is needed to help overcome the tendency in female students, especially, to view math as a male or irrelevant area for successful achievement. Perhaps the use of cognitive restructuring of math attitudes, combined with graded task assignments in mathematics, relaxation training, and exposure to successful role models, will help to empower students to reduce their own anxiety about mathematics.

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Table 1

Means and Standard Deviations for Mathematics Attitudes and Achievement of High and Low Math-Anxious Female College Freshmen

Variable	High Math-Anxious Subjects			Low Math-Anxious Subjects		
	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Mathematics Attitudes	63			53		
Confidence in Learning Mathematics		42.9	9.9		29.5	14.5
Math as a Male Domain		22.4	7.2		28.1	14.7
Usefulness of Mathematics		34.5	8.2		26.0	9.9
Mothers' Perceived Attitudes		34.5	6.5		30.3	12.4
Fathers' Perceived Attitudes		35.4	7.7		27.2	11.0
Teachers' Perceived Attitudes		38.8	7.3		28.7	11.7
Attitude Toward Success in Mathematics		29.8	6.4		30.2	14.4
Mathematics Achievement	63	33.4	7.8	53	38.5	13.0

Table 2

Relationship Between Mathematics Anxiety and Mathematics Attitudes and Achievement for High Math-Anxious Female College Students

Variable	Mathematics Anxiety	
	N	r
Mathematics Attitudes	63	
Confidence in Learning Mathematics		0.4957***
Math as a Male Domain		-0.3838***
Usefulness of Mathematics		-0.1386
Mothers' Perceived Attitudes		0.1214
Fathers' Perceived Attitudes		-0.2503*
Teachers' Perceived Attitudes		-0.0074
Attitude Toward Success in Mathematics		-0.3930***
Mathematics Achievement	63	0.0016

*p < .05
**p < .01
***p < .001

Table 3

Relationship Between Mathematics Anxiety and Mathematics Attitudes and Achievement for Low Math-Anxious Female College Freshmen

Variable	Mathematics Anxiety	
	N	r
Mathematics Attitudes	53	
Confidence in Learning Mathematics		0.6379***
Math as a Male Domain		0.5564***
Usefulness of Mathematics		0.8123***
Mothers' Perceived Attitudes		0.7199***
Fathers' Perceived Attitudes		0.7151***
Teachers' Perceived Attitudes		0.7702***
Attitude Toward Success in Mathematics		0.6201***
Mathematics Achievement		0.7056***

*$p < .05$
**$p < .01$
***$p < .001$

Table 4

Analysis of Variance of Scores on the Confidence in Learning Mathematics Scale by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	5194.078	1	5194.078	34.924*
Explained	5194.078	1	5194.078	
Residual	16954.449	114	148.723	
Total	22148.527	115	192.596	

*$p < .001$

Table 5

Analysis of Variance of Scores on the Math as a Male Domain Scale by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	924.986	1	924.986	7.341*
Explained	924.986	1	924.986	
Residual	14364.809	114	126.007	
Total	15289.797	115	132.955	

*$p < .01$

Table 6

Analysis of Variance of Scores on the Usefulness of Mathematics Scale by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	2095.757	1	2095.757	25.722*
Explained	2095.758	1	2095.758	
Residual	9288.434	114	81.477	
Total	11384.191	115	98.993	

*$p < .001$

Table 7

Analysis of Variance of Scores on the Mother Scale
by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	506.108	1	506.108	5.432*
Explained	506.109	1	506.109	
Residual	10622.383	114	93.179	
Total	11128.492	115	96.769	

*$p < .05$

Table 8

Analysis of Variance of Scores on the Father Scale
by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	1961.883	1	1961.883	22.309*
Explained	1961.883	1	1961.883	
Residual	10025.520	114	87.943	
Total	11987.402	115	104.238	

*$p < .001$

Table 9

Analysis of Variance of Scores on the Teacher Scale
by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	2927.969	1	2927.969	32.096*
Explained	2927.973	1	2927.973	
Residual	10399.684	114	91.225	
Total	13327.656	115	115.893	

*$p < .001$

Table 10

Analysis of Variance of Scores on the Attitude Toward Success in Mathematics Scale by Subjects' Math Anxiety (High or Low)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Math Anxiety	4.357	1	4.357	0.037
Explained	4.359	1	4.359	
Residual	13384.137	114	117.405	
Total	13388.496	115	116.422	

Table 11

Analysis of Variance of Scores on the Mathematics Anxiety Scale by Mothers' Occupation (Professional or Nonprofessional)

Source of Variation	Sum of Squares	df	Mean Squares	F
Main Effects				
Mothers' Occupation	0.046	1	0.046	0.000
Explained	0.047	1	0.047	
Residual	30519.0	330	92.48	
Total	30519.1	331	92.2	

Table 12

Analysis of Variance of Scores on the Mathematics Anxiety Scale by Fathers' Occupation (Professional or Nonprofessional)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Fathers' Occupation	141.1	1	141.1	1.49
Explained	141.1	1	141.1	
Residual	29433.9	311	94.6	
Total	29574.9	312	94.8	

Table 13

Analysis of Variance of Scores on the Mathematics Anxiety Scale by Mothers' Occupation (Math-Related or Non-Math-Related)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Mothers' Occupation	12.29	1	12.29	0.136
Explained	12.29	1	12.29	
Residual	28528.3	315	90.6	
Total	28540.6	316	90.3	

Table 14

Analysis of Variance of Scores on the Mathematics Anxiety Scale by Fathers' Occupation (Math-Related or Non-Math-Related)

Source of Variation	Sum of Squares	df	Mean Square	F
Main Effects				
Fathers' Occupation	256.9	1	256.9	2.75
Explained	256.9	1	256.9	
Residual	26696.6	286	93.3	
Total	26953.6	287	93.9	